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Economic Development and the Effects of Family Characteristics on Mathematics Achievement

This article explores the relationship between nations' level of economic development and the influence of adolescents' social backgrounds on their academic achievement. Using data from the Third International Mathematics and Science Study (TIMSS), the authors found that the positive effect of higher parents' education on middle-school students' mathematics test scores is remarkably consistent among the 34 nations examined. In contrast, the relative advantage of living in a traditional family for mathematics achievement varies systematically between nations, being significantly greater in those with stronger economies. Although the influence of socioeconomic status on educational stratification does not appear to change, the deepening academic disadvantage of living with only one natural parent in more developed nations may result from marginalization of families in these societies.

During the past 25 years, many sociologists and policy makers became concerned with the relatively poor academic performance of American school children, which has been partially attributed to an increasing number of nontraditional families (Astone & McLanahan, 1991; McLanahan & Sandefur, 1994). The assumption is that children living with only one parent, or a stepparent, lack access to social and economic resources vital for academic achievement and success in school. The rising numbers of children living with single parents in other Western nations has increased international interest in the relationship between family structure and children's academic success (Cochran, Larner, Riley, Gunnarsson, & Henderson, 1993; Pong, 1996). However, most studies of family structure are limited to only a few nations and do not explore the impact of economic development, culture, or public policy on the relative disadvantage of living in a nontraditional family.

In contrast, comparative education research has a long tradition of exploring cross-national differences in the effect of children's socioeconomic background on their academic achievement and educational attainment. One continuing debate concerns the impact of economic development on the association between parents' socioeconomic status and their children's academic success (Baker, Goesling, & LeTendre, in press; Blossfeld & Shavit, 1993; Heyneman, 1980; Simmons & Alexander, 1978). These arguments revolve around whether increasing economic and human resources in a nation alters the role of families, particularly the importance of social and motivational support for children, in educational stratification. If economic development influences the process

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of intergenerational transfer of socioeconomic status, then it may also affect the relative disadvantage of living in a nontraditional family.

The analyses in this article explore variation in the relationships between two aspects of adolescents' social backgrounds: (a) their parents' education, and (b) family structure, as well as mathematics achievement across 34 nations participating in the Third International Mathematics and Science Study (TIMSS). Using information from over 200,000 middle-school students (modal age is 13 years old), we examine the extent to which performance on the TIMSS mathematics test is related to these two indicators of adolescents' social backgrounds after taking into account their academic ability and orientation toward schooling. Hierarchical Linear Modeling (HLM) is used to determine the extent to which variations in the effects of parents' education and family structure on mathematics achievement are related to national levels of economic development.

Social Background and Mathematics Achievement

In the quarter of a century between 1972 and 1997, the percentage of 6- to 12-year-olds living with only their mothers doubled from 12% to 24% in the United States (National Center for Education Statistics [NCES], 1999). At the beginning of the new millennium, about half of all American children under 18 years old were estimated to have spent some time in a single-parent household, some from birth and many others as a result of separation and divorce. During the same period, other nations also experienced dramatic increases in single-parent families. By 1980 in Sweden, for example, a quarter of the families with young children contained only one parent (Cochran, Larner, Riley, Gunnarsson, & Henderson, 1993). Regardless of whether their single parent later marries, these adolescents have a greater risk than those living in traditional families of becoming teenage parents or getting in trouble with the law (McLanahan & Sandefur, 1994). Adolescents from nontraditional families are also more likely than those living with both their natural parents to experience academic difficulties (Lee, 1993), drop out of high school (Astone & McLanahan, 1991), and not complete a college degree (McLanahan & Sandefur).

Sociologists have developed two parallel explanations for why family structure influences children's success in school. One explanation focuses on the social dynamics within families, particularly the relationship between children and their parents. Both single-parent and stepparent families are often characterized as particularly stressful situations for children, partly as a result of high levels of interpersonal conflict (Sandefur & Wells, 1999). Single parents also often encounter difficulties providing their adolescents with emotional and other support (Astone & McLanahan, 1991) and adequately supervising their activities (Sandefur & Wells). A new spouse frequently exacerbates these difficulties by placing additional demands on the former single parent's time and energy (Sandefur & Wells). Thus, the argument goes, some children come to school with disadvantages arising out of social deficiencies inherent in the structure of their families.

In contrast, the other explanation focuses on the relationship between family structure and access to financial and community resources. The relative economic deprivation of single-parent families accounts for a significant proportion of the difference in academic achievement and attainment between adolescents in these and traditional families (Lee, 1993; McLanahan & Sandefur, 1994). Single parents also tend to have limited access to extended networks of relatives and friends, who often provide emotional and other types of support (Cochran et al., 1993). Although a family's economic and social conditions may improve when a single parent marries, stepchildren's access to vital financial and social resources still tends to be more limited than that of children living with both their natural parents (Sandefur & Wells, 1999). According to this perspective, improving access to external financial and social resources should help children from nontraditional families overcome their academic difficulties.

Similar arguments concerning the influence of family dynamics and access to external resources are put forward to explain why children of highly educated parents tend to excel academically and socially. Sociologists argue that children's likelihood of success in school and work is affected by differences in the values, expectations, and skills that parents may transmit to them (Sewell & Hauser, 1980). Parents with a college degree, for example, are more likely than parents with only a high-school diploma to check their children's homework and discuss school experiences with them (Muller & Kerbow, 1993). The success of these parents' children may reflect family values supporting hard work in school and high expec-

tations of academic success, as well as the academic skills and experiences of parents.

Parents' education, like family structure, is also related to access to financial and social resources that parents can use to further their children's educational careers. Greater financial resources allow more educated parents to purchase better homes, health care, and educational services. In addition, their experience and knowledge of the school system permit them to be more effective managers of their children's educational careers (Baker & Stevenson, 1986). More educated parents, for example, who are unable to afford private school tuition may still effectively insist their children be assigned to gifted programs, college preparatory courses, or classes of particularly good teachers in public schools. In contrast, children of less well-educated parents are likely to have limited access to quality educational services, whether because of the schools they attend or the classes to which they are assigned.

Economic Development and Educational Stratification

The two distinct perspectives—focusing on deficiencies within families versus differential access to external resources—provide little insight into the impact of broader social, political, and historical contexts in which families and schools are embedded. Economic development, in particular, may influence the process of educational stratification through changes in the availability of economic resources, demographic trends, and cultural or financial inequality (Heyneman & Loxley, 1983). Whether the effects of economic development weaken or strengthen the association between adolescents' social background and academic success is hotly debated.

The classic modernization theory proposes that economic development alters the process of educational stratification by increasing the importance of individual talent and effort for academic and occupational success (Parsons, 1970). More developed nations have the economic resources to establish institutional infrastructures that provide at least minimal levels of educational and other services important for adolescents' academic success (Blossfeld & Shavit, 1993). These increasing educational opportunities should allow motivated and able adolescents from all social groups to progress in school. Thus, the influence of social background on academic achievement should decrease with the rise of meritocracies in more economically developed nations (the rising meritocracy hypothesis).

Some cross-national research, however, indicates that the relationship between children's social backgrounds and academic achievement is stronger in developed nations compared to developing nations (Heyneman & Loxley, 1983; Simmons & Alexander, 1978). Coleman (1990) argued that industrialization removes families from a society's economic core, reducing incentives for parents to invest in their children. Ironically, intangible resources such as parents' time and attention that support children's academic efforts become scarce at the same time tangible resources such as schools and textbooks become universally available. A strong economy may also affect a nation's social system through, for example, higher rates of residential mobility that reduce the stability of social networks, which provide external supports especially important to single parents (Cochran et al., 1993). Thus, paradoxically, an individual child's academic achievement should be more strongly influenced by his or her social background as economic development marginalizes the financial and social functions of families in a society (the marginalized families hypothesis).

Recent cross-national studies, however, found no differences related to nations' levels of economic development in the association between children's social background and their academic achievement or attainment (Baker et al., in press; Blossfeld & Shavit, 1993). Despite the dramatic expansion of educational opportunities in developed nations, more affluent parents still maintain the ability to pass their educational advantage on to their children (Bowles & Gintis, 1976). Other social changes, such as government policies or high rates of immigration, may temporarily disrupt this pattern of social reproduction. Once a new elite is established, however, its members may use their advantages to pass their social status on to their children. Thus, the influence of social background on academic achievement should remain fairly stable regardless of economic development (the social reproduction hypothesis).

These theories predict very different patterns in the association between social background and academic success as economic development increases: weakening associations by the rising meritocracy hypothesis, strengthening associations by the marginalized families hypothesis, and no change in associations by the social reproduction hypothesis. In this article, we explore how the ef-

fect of two social background indicators—parents' education and family structure—are associated with national levels of economic development. To do this, we conducted two sets of analyses: (a) we estimated ordinary least squares (OLS) regression models using the same independent and control variables for each nation, and (b) we used hierarchical linear modeling (HLM) to estimate interaction effects between individual-level and nation-level factors. Both sets of analyses include controls for adolescents' academic ability and orientation toward mathematics. We are particularly interested in whether the effects of both social background variables are similarly associated with economic development, providing consistent support for one of the theories discussed above.

Methods

The Sample

TIMSS, a large and comprehensive international comparative study of mathematics and science achievement, was conducted by the International Association for the Evaluation of Educational Achievement (IEA) in the latter part of 1994 through 1995. For these analyses, we used the TIMSS Population 2 component, which consists of about 250,000 students in the two grades enrolling the largest percentages of 13-year-olds, usually Grades 7 and 8, from more than 40 nations. (For information on the other TIMSS populations, see Robitaille & Garden, 1996.) This group was selected because middle-school education is usually compulsory, almost universal, and relatively undifferentiated in the participating nations (Robitaille, 1997) and the respondents are old enough to provide reasonably reliable information on their social background and educational experiences. The sample used in this article consists of respondents from the 34 TIMSS nations that collected information about participants' family structure and parents' education. The final sample consisted of 219,402 students, with an average of 6,453 per nation. Table 1 lists the nations used for these analyses and their sample sizes.

TIMSS used a two-stage stratified cluster sample design. First, in each nation at least 150 schools were sampled with a probability proportionate to their enrollment and stratified by factors such as geographic region and public or private sector. In the second stage, at least one classroom of students at each of the two grade levels were randomly sampled from each school. For this article, the data were weighted to account for the complex sample design and to adjust for nonresponse. We used the *house weight,* which standardizes within nations students' probabilities of participating such that the weighted and actual sample sizes are the same (Gonzalez & Smith, 1997).

Table 1. Regional Classification, GDP Level and Rank, and Sample Size for 34 Nations

Region	GDP /$1,000	GDP Rank	Sample size
European			
Austria (AUT)	20.38	10	4,993
Belgium (Flemish speaking) (BFL)	20.70	9	5,341
Belgium (French speaking) (BFR)	20.70	8	4,228
Switzerland (CHE)	24.10	2	10,602
Germany (DEU)	19.49	13	5,065
France (FRA)	20.18	12	5,230
Ireland (IRL)	15.53	20	5,539
Netherlands (NLD)	18.94	14	3,652
Scotland (SCO)	18.36	16	5,048
Scandinavian			
Denmark (DNK)	20.94	6	3,677
Iceland (ISL)	20.21	11	3,128
Norway (NOR)	20.95	5	4,886
Sweden (SWE)	18.08	17	7,531
Immigrant			
Australia (AUS)	18.78	15	11,824
Canada (CAN)	20.94	7	15,017
Israel (ISR)	16.70	18	1,210
New Zealand (NZL)	16.65	19	6,026
United States (USA)	26.15	1	9,988
Mediterranean			
Spain (ESP)	14.21	21	7,072
Greece (GRC)	11.50	23	6,949
Portugal (PRT)	12.42	22	5,919
Baltic/Central European			
Czech Republic (CSK)	9.35	26	6,338
Hungary (HUN)	6.45	27	5,410
Lithuania (LTU)	3.99	31	4,062
Latvia (LVA)	3.36	33	4,221
Slovak Republic (SLV)	6.27	28	6,780
Eastern European			
Romania (ROM)	3.98	32	6,637
Russian Federation (RUS)	4.50	30	7,030
Slovenia (SVN)	10.20	25	5,228
Industrialized Asian Pacific			
Hong Kong (HKG)	22.20	4	6,341
Korea (KOR)	11.15	24	5,712
Singapore (SGP)	22.88	3	8,133
Nonindustrialized Southern Asian Pacific			
Philippines (PHL)	3.10	34	10,126
Thailand (THA)	5.83	29	10,459

National Characteristics

These analyses focused on whether nations' levels of economic development are related to interna-

tional variation in the relationships between mathematics achievement and adolescents' social background. Our measure of economic development was the per capita gross domestic product (GDP), obtained from *The World Development Indicators 1998 CD-ROM* published by the World Bank. GDP estimates "the total output of goods and services for final use within the domestic territory of a given country." The unit of measurement is *international dollars*, which have the same purchasing power as dollars in the United States. For these analyses we rescaled the variable, which has a mean of 3.10 and standard deviation of 6.973, to be $1,000 per capita. Table 1 shows each nation's GDP level and rank within the 34 nations used for this study.

Nations with similar levels of economic development, however, can vary dramatically in the demographic, political, and cultural characteristics that may also affect the relationship between adolescents' social backgrounds and academic achievement. For our first set of analyses, results were obtained separately for each nation, as is frequently done in other cross-national studies of academic achievement (for example, see Baker et al., in press; Peak, 1996; Stevenson & Baker, 1991).

However, we developed a classification scheme to at least partially control for nation-level differences related to geographic region and historical similarities in the HLM analyses. We initially considered grouping nations similarly to the eight regional classifications used by Schmidt, Raizen, Britton, Bianchi, & Wolfe (1997) to indicate geographic, historic, and cultural proximity of nations participating in TIMSS. This scheme reflects broad cultural differences, such as the Confucian philosophy of many Asian Pacific nations compared to the Judeo-Christian philosophy of European nations. However, we felt that some of the larger groupings of nations failed to reflect clear cultural, linguistic and climatic differences within the group. For example, among nations often referred to as Western Europe, we felt that the Nordic heritage of Scandinavian nations contrasts sharply with the Latin heritage of Mediterranean nations. Similarly, we divided Asian Pacific nations into two groups—industrialized and nonindustrialized—because the dramatic differences in GDP failed to statistically account for differences in average test scores between the two groups. A review of research by Buchmann & Hannum (2001) suggests that expansion of educational opportunities had a very different impact on the association between social background and educational attainment in each Asian Pacific group.

We also differed from Schmidt et al. (1997) by grouping together Australia, Canada, Israel, New Zealand, and the United States as *immigrant nations* because they share the common characteristics of (a) the vast majority of population migrated to each from another geographic area within the last 200 years, and (b) being former British colonies or having had close ties to Britain at one time. We hypothesized that the relatively young social structures of these nations might be related to weaker associations between social background and academic achievement. A similarly weak relationship might be expected in former Soviet Union nations because Socialist government policies were intended to eliminate social class differences. Additionally, however, we separate these nations into two groups—Baltic-Central European nations and Eastern European nations—to reflect cultural differences associated with proximity to Western Europe. The final eight nation groupings used in the HLM analyses are shown in Table 1.

Dependent Variable: Mathematics Achievement

The dependent variable in these analyses was mathematics achievement, which is based on adolescents' performance on a test administered as part of TIMSS to measure their mastery of the established mathematics curriculum common in most nations. Participants' total test scores were imputed using Item Response Theory from their responses on the subset of items in their test booklets and the performance of other participants on those and other items (Gonzalez & Smith, 1997). The test scores were standardized with a mean of 500, a standard deviation of 100, and a maximum possible score of 1,000. (For comparisons of international differences in academic performance on the TIMSS achievement tests, see Peak, 1996.)

Independent Variables: Family Structure and Parents' Education

Participants' reports of the highest level of education achieved by either of their parents were used here as the indicator of their families' socioeconomic status. The variable had five categories, ranging from 1 = *finished primary school* to 5 = *finished university*. Preliminary analyses showed a reasonable linear trend in average mathematics achievement across the five categories in all the

nations, so the measure was used as a scale variable here. If adolescents either did not know their parents' education level or did not respond to the question, this variable was coded as the average parents' education for their nation and a dummy variable indicating missing values on this variable was coded as 1. Because TIMSS provided no internationally comparable measure of family income, parents' education was used in these analyses as a measure of both human and financial capital available in a family.

For these analyses, the indicator of family structure was based on adolescents' reports of the adults living in their household. The variable was coded as 1 when adolescents reported they were living with both their mother and father, and coded 0 if they were living with only one or neither of their parents. We decided to use this dichotomous indicator because (a) several nations did not include questions concerning stepparents or other adults living in the household, (b) supplementary analyses using indicators for various types of nontraditional families produced substantively identical findings, and (c) the coefficients for one indicator variable were easier to compare across nations in both the OLS and HLM analyses because they indicated the average difference in mathematics test scores between adolescents living in traditional compared to those in nontraditional families.

Control Variables

In these analyses, we included as control variables measures of adolescents' academic ability, reflected in their relative educational progress, innate talent, and orientation toward schooling and mathematics. Because of the sampling structure of TIMSS, students' age and year in school (grade level) must be taken into account when comparing mathematics test scores both within and across nations. We used students' scores on the TIMSS science test and their level of agreement with the statement "I usually do well in mathematics" as proxy measures for academic talent because TIMSS did not include any measures of students' prior achievement, such as earlier test scores or grades. Our measures of students' attitudes toward mathematics were based on their reports of the number of hours they spent studying mathematics each day outside of school and how much they liked the subject. Gender, which is often related to performance in mathematics, was also included as a control variable in the models. Using these control variables dramatically reduced the unexplained variation in mathematics test scores, which were strongly correlated with science scores in all nations. This means that the coefficients for the social background variables reflected the relative effect on mathematics achievement of having more educated parents or living with both parents after taking into account individual differences in academic ability and attitudes toward mathematics.

Analysis Techniques

The question of whether the relationships between mathematics achievement and adolescents' social backgrounds vary across nations requires a multilevel analytic strategy. The first set of analyses presented in this article explored the differences across nations in the effects of parents' education and family structure by estimating the same OLS regression model separately for each of the 34 nations. Comparing the coefficients across nations ranked by GDP provided a first look for trends in the effect of social background associated with increasing levels of economic development. Comparisons using a wide variety of other nation classification strategies are also possible using this approach.

The second set of analyses statistically modeled differences in the coefficients for these family background variables using HLM, a common technique for analyzing data from cluster samples (in this case, students nested within nations), that allows simultaneous consideration of factors from two levels of analysis (Bryk & Raudenbush, 1992). HLM uses an iterative process to alternately estimate regression models within each cluster (Level 1) and equations modeling the differences in the Level 1 coefficients between the clusters (Level 2).

The student-level (Level 1) model for this analysis is shown in Equation 1, where β_{0j} to β_{10j} were the coefficients for the individual characteristics within each nation. The term e_{ij} provided a measure of the random error, which included unmeasured sources of variation, in a particular student's outcome. For our HLM analyses, each student-level variable was centered around its grand mean for the entire sample to allow the intercepts (β_{0j}) to be interpreted as the mean mathematics test score adjusted for the characteristics of students in each nation (Bryk & Raudenbush, 1992). The Student-level model (Equation 1) is as follows:

TABLE 2. HLM ANALYSIS OF INTERNATIONAL DIFFERENCES IN MIDDLE SCHOOL STUDENTS' MATHEMATICS TEST SCORES IN 34 NATIONS

	Model I		Model II	
Fixed Effects	Coefficient (γ_{ks})	*SE*	Coefficient (γ_{ks})	*SE*
Adjusted mean				
Intercept (γ_{00})	512.314***	5.715	512.311***	2.809
GDP (γ_{01})			1.175*	.464
Immigrant (γ_{02})			−36.110**	11.180
Mediterranean (γ_{03})			−33.955***	3.854
Industrialized Asian Pacific (γ_{04})			70.377***	5.048
Students' social background				
Parents' education (γ_{10})	7.294***	.337	7.263***	.336
Living w/both parents (γ_{20})	5.662***	.851	5.801***	.573
GDP (γ_{21})			.392***	.071
Eastern European (γ_{22})			−6.370***	1.414
Control variables (γ_{30}–γ_{80})				
Age	−8.511***	1.450	−8.502***	1.448
Grade level	25.350***	1.920	25.353***	1.913
Science test score	.461***	.009	.461***	.009
Good in math	18.691***	1.510	18.696***	1.511
Hours study	−3.959***	.871	−3.964***	.869
Likes math	7.062***	.611	7.064***	.610
Male	−3.68***	.768	−3.676***	.768
Missing parents' education	−10.731***	.732	−10.730***	.730
Variance Components				
Between nations[a]				
Intercept (u_{0j})	1,100.549***		257.835***	
Parents' education (u_{1j})	6.623***		6.625***	
Living w/both parents (u_{2j})	24.631***		10.094***	
Within nations (e_j)	4,622.494		4,622.560	

Note: GDP = gross domestic product.
[a]The test for significant variation in the error components (u_{kj}) follows a chi-square distribution with the test statistic calculated as described in Bryk & Raudenbush (1992).
*$p < .05$. **$p < .01$. ***$p < .001$.

$$Y_{ij} = \beta_{0j} + \beta_{1j}(\textit{Parents' Education}_{ij}) + \beta_{2j}(\textit{Family Structure}_{ij}) + \beta_{3-10j}(\textit{Control Variables}_{ij}) + e_{ij} \quad (1)$$

For the model, the control variables were set to have the same effect for all nations and were not modeled on the nation level (Level 2). Preliminary analyses indicated that in TIMSS, the association between adolescents' mathematics and science test scores did not vary significantly between nations. These analyses also showed that the student-level coefficients for age, grade, and studying hard were strongly correlated, requiring that the effects of these three variables not be allowed to vary (i.e., should be fixed) across nations for proper estimation of the HLM models (Bryk & Raudenbush, 1992). Although the student-level coefficients for the other control variables varied significantly between the nations, we decided to also fix these effects because the goodness-of-fit measure was decreased by less than .1% using this more parsimonious HLM model. This procedure also did not affect our results because (a) variations in the control variable coefficients were not related to GDP and (b) fixing these effects did not significantly change the size or the significance levels of coefficients for the social background variables. Results for this student-level model before entering any nation-level variables are shown in the column labeled Model I in Table 2.

The nation-level (Level 2) model estimated the extent to which variations in the student-level coefficients for individuals' social background were related to GDP, controlling on regional classification. Equation 2 shows the general model for estimating these relationships, in which nation-level intercepts (γ_{k0}) were the average coefficient for either the intercepts (adjusted means) or social background variables across nations. The term u_{kj} was a measure of the error in estimation of the student-level coefficients for each nation. The co-

efficients for the national characteristics (γ_{k1} to γ_{ks}) were adjustments to, or interactions with, the average student-level coefficients. The relationship between a social background variable and mathematics achievement was amplified when the coefficients for the average effect and interaction term were in the same direction. The nation-level model (Equation 2) is as follows:

$$\beta_{kj} = \gamma_{k0} + \gamma_{k1}(GDP_j) + \gamma_{k2-s}(region_j) + u_{kj} \quad (2)$$

Initially, we used the same nation-level model (as shown in Equation 2) that included GDP and all the region indicators as predictors of the coefficients for the intercepts and each social background variables. To develop a parsimonious final model, however, we gradually eliminated from our models for each student-level coefficient terms for national characteristics that were not statistically significant. Thus, the nation-level model differed for the intercept, the effect of parents' education, and the effect of family structure. This procedure did not affect the results for any particular variable given the high (over .80) reliability indicators for the student-level coefficients. The combined model estimated in the final HLM analyses (Model II in Table 2) is shown in Equation (3):

$$\begin{aligned} Y_{ij} = {} & [\gamma_{00} + \gamma_{01}(GDP_j) + \gamma_{02-s}(region_j) + u_{0j}] \\ & + [\gamma_{10} + u_{1j}](Parents'Education_{ij}) \\ & + [\gamma_{20} + \gamma_{21}(GDP_j) + \gamma_{22-s}(region_j) \\ & + u_{2j}](FamilyStructure_{ij}) \\ & + [\gamma_{30-10}](ControlVariables_{ij}) + e_{ij} \end{aligned} \quad (3)$$

Results

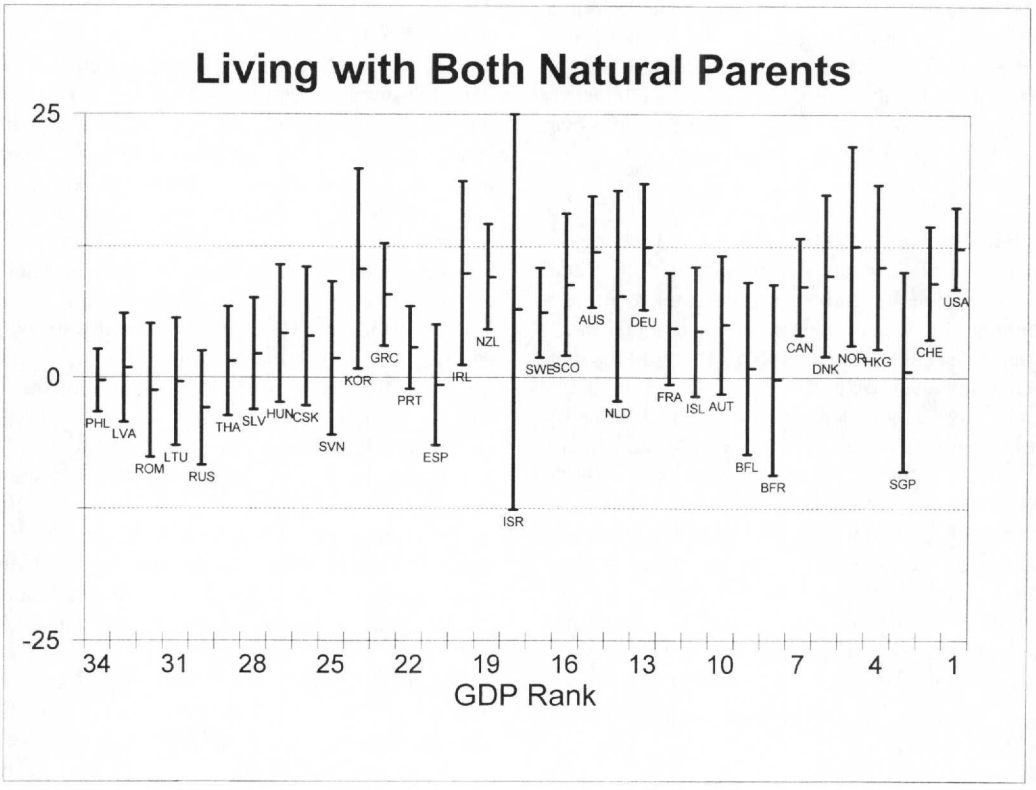
The purpose of these analyses was to determine whether the relationships between various aspects of adolescents' social background and mathematics achievement varied across nations and to explore whether these variations were related to international differences in economic development. To get a preview of these relationships, we estimated for each nation an OLS regression model using the same variables for each nation. Figure 1 shows the 99% confidence intervals ($p < .01$) for family structure coefficients from each of the 34 nations, ordered by GDP rank. Showing the estimated margin of error, confidence intervals crossing the zero line indicate that the coefficient was not statistically significant at $\alpha = .01$. Also, overlapping ranges of confidence intervals for two countries indicates that the two coefficients were not statistically different from each other at $p < .01$.

The trends in Figure 1 suggest that the effect of family structure on mathematics achievement varied systematically between nations, controlling on parents' education and academic ability. For just under 60% of the nations, the 99% confidence intervals for the adjusted average difference in mathematics test scores between adolescents in traditional compared to those in nontraditional families included zero, indicating that the coefficients were not statistically significant at $\alpha = .01$. However, Figure 1 shows that the family structure coefficients tended to be larger in nations with higher GDPs. None of the coefficients for the 10 nations with the lowest GDPs were statistically significant. In contrast, six of the coefficients for the 10 nations with the highest GDPs were statistically significant and positive. This suggests that the advantage of living with both parents was larger in nations with stronger economies. However, many of the confidence intervals overlapped, indicating that this pattern may have occurred by chance.

In contrast, all but one of the 99% confidence intervals for parents' education in Figure 2 did not include zero, indicating children with more educated parents tended to perform better on the mathematics test in almost all of the nations. Canada was the exception, although the coefficient for this nation was statistically significant at the 95% confidence level ($p < .05$). Also, except for the extreme cases of Hungary and the Philippines, most of the confidence intervals for the other nations overlapped each other, suggesting that they were not statistically different from each other ($p < .01$). In addition, the figure does not show any clear pattern in the relationship between parents' education and mathematics achievement across GDP rank.

We used HLM to statistically test whether international variation in the relationships between academic achievement and family structure or parents' education were significantly related to GDP. The results of these analyses are contained in Table 2, with coefficients for the student-level variables of interest and national characteristics shown in the top panel (fixed effects). The middle panel contains the coefficients for the control variables and the unaccounted-for variation in mathematics test scores is shown in the bottom panel (variance components). The coefficient for grade level (25.350) is used for discussion purposes in

FIGURE 1. 99% CONFIDENCE INTERVALS FOR OLS REGRESSION COEFFICIENTS FOR FAMILY STRUCTURE IN 34 NATIONS, RANKED BY GDP



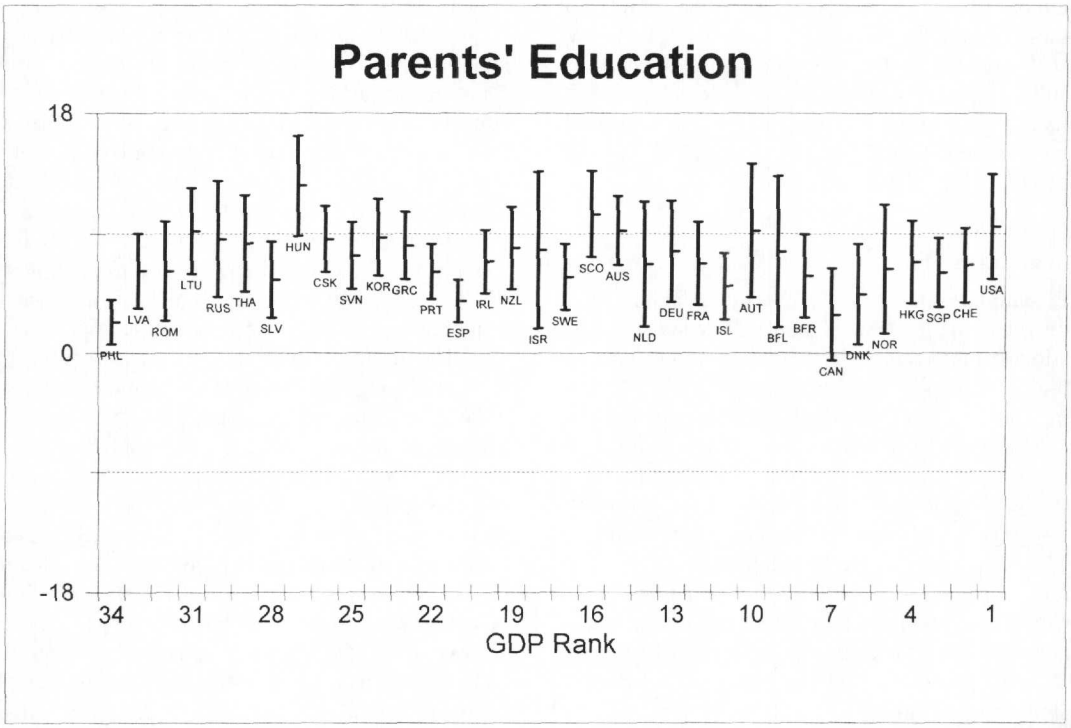
this article as an estimate of the average expected gain in mathematics test scores for one school year among these 34 nations. Model I was a random coefficient model that was used to estimate the percentage of variation in individual mathematics test scores that occurred across nations (Bryk & Raudenbush, 1992). Model II examined whether variations in the student-level coefficients for these variables were related to GDP.

The results for Model I were consistent with research on mathematics achievement in the middle grades. Overall, adolescents with more educated parents or living with both parents tended to earn higher scores on the mathematics test. For each additional level of education their parents obtained, adolescents scored an average of 7.294 points (about 28.8% of a year's gain) higher on the test. On average, adolescents living with both parents scored 5.662 points (about 22.3% of a year) higher on the test than those living in nontraditional families. These results suggest that adolescents' social backgrounds significantly influenced their mathematics achievement, even after taking into account their academic ability and orientation toward schooling.

However, as shown in the bottom panel of Table 2, there was statistically significant variation in Model I across nations in the relationships between adolescents' mathematics achievement and social background. Almost 20% [(1,100.549 + 6.623 + 24.631)/(1,100.549 + 6.623 + 24.631 + 4,622.494)] of the unaccounted for variation in mathematics test scores occurred between nations, most of which was associated with differences in nations' average mathematics test scores (u_{0j}). However, statistically significant amounts of unexplained variation in mathematics test scores were related to differences across nations in the relationships between mathematics scores and parents' education (u_{1j}) or family structure (u_{2j}).

To determine whether variation in the effects for family structure and parents' education were related to economic development, we added indicators for GDP and region to the analyses. Only

FIGURE 2. 99% CONFIDENCE INTERVALS FOR OLS REGRESSION COEFFICIENTS FOR PARENTS' EDUCATION IN 34 NATIONS, RANKED BY GDP



terms for nation-level variables with statistically significant effects on student-level coefficients were include in Model II. First, even taking into account differences in adolescents' social backgrounds along with their academic ability and orientations, more economically developed nations tended to have somewhat higher average mathematics test scores. In addition, adolescents in industrialized Asian Pacific nations tended to earn higher average mathematics test scores, and those in immigrant and Mediterranean nations earned lower average scores compared to those in other nations. The results in the bottom panel indicated that over 76.6% [.766 = (1,100.549−257.835)/1,100.549] of the previously unexplained variation in the adjusted mean mathematics tests scores between nations was accounted for by GDP and the three region indicators.

Second, as indicated by their absence from Model II, none of the nation-level variables was significantly related to variation in the effect of parents' education on mathematics achievement, reflecting the lack of systematic differences suggested earlier in the OLS analyses. Future analyses may identify other national characteristics that account for differences in the effect of parents' education, but sampling or measurement error may also have created the appearance of international variation in this relationship.

Finally, the trend in the relationship between family structure and mathematics achievement seen in Figure 1 was confirmed by Model II. The relative advantage of living with both parents was significantly larger in nations with higher GDPs. A one standard deviation change in GDP was estimated to strengthen the relationship between family structure and mathematics achievement by just over 47% [.471 = (.392*6.973)/5.801]. This change was equivalent to adding about a tenth of a year [.108 = 2.733/25.350] to the adjusted average difference in mathematics scores between the two types of families per standard deviation change in GDP. The results also indicated that there was virtually no difference (i.e., 5.801 − 6.370 = −0.569) in average mathematics test scores between adolescents living in traditional and nontraditional families in Eastern European nations, after taking into account differences in

parents' education and adolescents' academic ability. Together, GDP and region accounted for almost 60% [.59 = (24.631−10.094)/24.631] of the variation in the relationship between family structure and mathematics test scores. These results suggest that, like average levels of achievement, the relative advantage of living with both natural parents was related to nations' level of economic development.

Discussion

In summary, our results suggest that the influences on mathematics achievement of some aspects of adolescents' social background are more sensitive than others to national economic conditions. Taking into account individual differences in academic ability and orientation toward schooling, both parents' education and living in traditional families were positively related to higher mathematics test scores in these 34 nations participating in TIMSS. However, we found no discernable pattern across nations in the effect of parents' education on middle-school students' mathematics achievement related to national levels of economic development. In contrast, both our OLS regression analysis and HLM results suggest that the effect of family structure was significantly stronger in nations with higher GDPs. Other HLM analyses (not presented here) indicated that, although still significantly lower than those living with both parents, adolescents living with only one parent tended to have higher mathematics test scores than those living with a stepparent or neither of their natural parents. However, the relative disadvantage of living in a nontraditional family, regardless of the type, was significantly greater in more affluent countries.

One weakness of TIMSS is that the information on family structure is limited to adolescents' reports of who lives in their household. Analyses of differences in academic achievement related to the processes leading to living in a nontraditional family, such as reasons for and timing of single parenthood, are not possible with TIMSS. Although the proportion of adolescents living with both parents is not significantly correlated with GDP among TIMSS nations, the likelihood of a single parent being divorced or never-married may be related to a nation's level of economic development. If single mothers in less developed nations tend to be widows, then the lack of significant differences related to family structure may be the result of greater amounts of material support widows tend to receive from family members compared to divorced or never-married mothers (Pong, 1996).

Another weakness of TIMSS is the relatively small number of developing nations, especially in Latin America and Africa, where the process of educational stratification may be very different than in industrialized regions (Buchmann & Hannum, 2001). These are also nations where significant numbers of 13-year-olds from poor families may be unable to attend school. Although the TIMSS nations tend to be relatively affluent, they do vary in many other ways that might impact academic achievement and educational stratification. The groupings used in this article were mostly based on geographic region, which captures only gross differences related to location and some very broad historical patterns. Better indicators of these nations' cultural and political differences, especially relating to provision of social services and school systems, are needed. Such measures may be particularly useful in three-level HLM models exploring the relative contribution of classroom resources to adolescents' academic achievement, which may be affected by systemic features such as teacher certification requirements, degree of centralization, and types of assessments. We used a two-level model for our analyses here because we are testing macro-level hypotheses about the effect of GPD on the relationship between academic achievement and social background.

Our results provide no support for the meritocracy hypothesis proposed by classic modernization theory because the influence of social background on mathematics achievement did not weaken as economic development increased. As we do here, analyses of international data consistently find higher levels of average academic achievement and educational attainment in more economically developed nations than in less developed nations (e.g., Baker et al., in press; Heyneman & Loxley, 1983). However, we find no evidence that, among highly developed nations, expanded educational opportunities decreased the influence of social background, increasing the importance of individual motivation and ability, in the process of educational stratification.

Our results for family structure do support the hypothesis that greater economic development marginalizes the role of families in society, increasing the influence of intangible social resources in the process of educational stratification. The greater relative advantage of living with two par-

ents in more developed nations suggests an increasing importance of parents' strategic investments of time and attention for their children's academic success (Coleman, 1990; Heyneman & Loxley, 1983). The demands single and remarried parents have on their time and energy may cause these intangible resources to be especially lacking in nontraditional families in these nations (McLanahan & Sandefur, 1994). In addition, industrialized nations tend to have more geographically mobile populations and smaller families, reducing the availability of these social supports and other intangible resources through extended family or community networks (Buchmann & Hannum, 2001). In the United States and Sweden, even after taking into account social status, a significant amount of the disadvantage of living in a nontraditional family is related to a higher likelihood of residential mobility (Cochran et al., 1993). Further cross-national research is needed to determine whether social policies, such as providing quality daycare or housing assistance, will mitigate the academic problems of adolescents from nontraditional families.

In contrast, the relative similarity of the effect of parents' education on mathematics achievement across nations supports the social reproduction hypothesis that elites will use the educational system to pass their social status on to their children. Regardless of national context, more educated parents appear to be able to provide their children with academic and social supports important for educational success. These parents also have access to a wide variety of economic and other resources that can be drawn upon to help their children succeed in school.

What may differ between nations, however, is the importance of particular internal supports and external resources in the process of social class reproduction. Educational and social policies, for example, may reduce the relative advantage of having rich parents by equalizing access to schooling and standardizing opportunities for learning (Jonsson, Mills, & Muller, 1996; Stevenson & Baker, 1991). However, more educated parents can still draw on their social and cultural capital to create more positive and supportive relationships with schools and teachers, which influence their adolescents' academic success (Cochran et al., 1993; Ho, 2000). Although difficult with TIMSS, separate indicators for parents' education and family income would permit international comparisons of the importance of human capital compared to financial capital as predictors of adolescents' academic success. Such analyses could explore whether variation in the particular strategic investments made by more educated parents is associated with the broader societal contexts.

In conclusion, we expect that efforts to assist adolescents from nontraditional families to achieve at the same levels as those living with both of their parents will be more effective than policies designed to reduce social class inequality. In less developed nations, children's academic performance does not appear to be related to the type of family in which they live. This finding suggests to us that concerns that the rising number of single parents are a cause for the relatively poor academic performance of American adolescents are misplaced. The problem is more likely related to larger cultural and demographic trends associated with economic development that create difficulties for adolescents regardless of whether they are living in a nontraditional family or not. However, the complex roles families play in adolescents' academic achievement means that successfully reducing differences related to family structure may not address more deeply ingrained inequality related to social class.

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